International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 2, Apr 2018, 857-864

PERFORMANCE ANALYSIS OF DIESEL ENGINE USING HAZEL NUT BIODIESEL WITH ANTIOXIDANTS

N. PRABHU KISHORE[1], P. BRIDJESH[2] & ALEKHYA. N[3]

[1,2]Department of Mechanical Engineering, MLR Institute of Technology, Hyderabad, India

[3]Department of Aeronautical Engineering, MLR Institute of Technology, Hyderabad, India

ABSTRACT

Experiments have been conducted using hazelnut biodiesel with L-ascorbic acid as antioxidant. The physiochemical properties of test fuels are suitable to be used as fuels on diesel engine. With a addition of the antioxidant, NOx emission reduced drastically with hazelnut biodiesel. The performance and emission characteristics of hazel nut biodiesels are compared with diesel and discussed.

KEYWORDS: Antioxidant, Biodiesel, NOx, CO & HA20

Received: Feb 11, 2018; **Accepted:** Mar 02, 2018; **Published:** Mar 15, 2018; **Paper Id.:** IJMPERDAPR201898

Original Article

INTRODUCTION

With the demand in energy consumption, the cost of importing large quantities of petroleum fuel has increased enormously in developed and developing countries. There will be a significant impact on the economy and environment if part of the total petroleum consumption had been substituted by some other means [1]. With this, energy management techniques, energy efficient systems, socio- economic protection and utilization of alternative fuels have become areas of interest among researchers. The quest for alternative fuels which are renewable, easily available, and sustainable and eco friendly are of prime important [2]. Biodiesels produced from vegetable oils are such a promising fuels in the present scenario [3]. Research established on various biodiesels revealed that the physiochemical properties of most of biodiesels are almost similar to diesel and can be used on diesel engines without much modifications on the existing engines [4,5]. Out of the various biodiesels used, hazel nut oil utilization on engine has not been comprehensively studied. Nonetheless, Metin [6] conducted tests on engine fuelled with 5%, 20% and 50% hazelnut oil methyl ester. The comparison of physiochemical properties of hazelnut biodiesel showed that viscosity of 100% hazelnut biodiesel is very high (5.4cSt) than diesel. Also, the density is higher (884.3) than diesel. Performance and emission characteristics reveal that brake thermal efficiency of 20% blend of hazelnut biodiesel is higher than other blends. While the engine exhaust emissions such as HC, CO and NOx have increased with increase in blend ratio than diesel. Ayhan et al., [7] compared performance of engine fuelled with blends of hazelnut with other biodiesels. They concluded that BTE with 30% blend of hazelnut oil decreased by 3.1% while there was substantial increase in NOx emission. Saydut et al., [8] studied the characterization of hazelnut biodiesel and concluded that the additives used in production and transesterification of biodiesel plays a very significant role. Efe et al., [9]. Experimented hazelnut biodiesel in proportions of 20%, 50% and 100% on a diesel engine at varying speed. It was concluded that 20% hazelnut biodiesel produces good performance on the engine while NOx emission is higher than diesel. Yu and Hanna [10] established

characterization of hazelnut biodiesel and concluded that oxidative stability and flowability is higher than other biodiesel. Also, the average heating value of hazelnut biodiesel is almost similar to diesel. Kocak [11] studied the performance and emission parameters using hazelnut biodiesel on a turbocharged diesel engine. It was found that lower heating value of hazelnut biodiesel is lower than diesel thus BTE is as well low. High amount of NO_x, HC and CO have been recorded than diesel. Demirbas [12] carried out supercritical fluid extraction method using N-hexane and methanol as solvents and obtained 25.7 – 38.5% of yield. At man [13] investigated the effects of cetane improver on blends of biofuels such as n-butanol, 10pentanol and hazelnut biodiesel. Alcohols have lower cetane number thus; 2-EHN was used in proportions of 500, 1000 and 2000 ppm. With addition of 2-EHN, there was notable reduction in BSFC. However, NOx, CO emissions increased drastically.

From the above literature, it is evident that NOx emission is higher than diesel for all blends of hazelnut biodiesel. Higher NOx was formed due to higher peak combustion temperature. Hardware modifications to mitigate NOx emissions are costlier. Addition of antioxidants can reduce combustion peak temperature which in turn reduces the formation of NOx. The aim of present study is to investigate the influence of antioxidant on the performance and emission of a diesel engine. In this regard antioxidant, L-ascorbic acid is used in proportions of 100 mg with hazelnut biodiesel of 20% composition and 80% diesel (HA20). The alternative fuels used in this study are HA20 and neat hazelnut biodiesel (H20) and the results are compared with diesel.

EXPERIMENTAL SETUP AND PROCEDURE

Tests were conducted on a single cylinder diesel engine having rated power of 5.2kW at 1500 rpm. The detailed description of setup is presented in [14]. Before starting the engine, lubricating oil level and cooling water supply were checked and ensured. The standard operating procedure of conducting tests as per the manual has been adopted. The specifications of the engine are presented in Table 1 and engine setup is shown in Fig. 1. The test fuels used in this study were diesel, palm biodiesel 20% + diesel 80% by vol. (PB20) and palm biodiesel 20% + diesel 78% + soy-lecithin 2% (PBS20). Tests were carried out at 25%, 50%, 75% and 100% load to analyze performance and emission characteristics and compared with diesel. The physiochemical properties of test fuels are shown in Table 2.

Table 1: Engine Specifications

Make and model	Kirloskar, TV1
Number of cylinders	1
Bore, mm	87.5
Stroke, mm	110
Combustion chamber	Hemispherical
Piston bowl	Shallow bowl
Compression ratio	17.5:1
Rated power, kW	5.2
Rated speed, rpm	1500
Fuel injection type	Direct injection
Number of nozzle holes	3
Fuel injection pressure, MPa	22
Fuel injection timing, °CA bTDC	23
Dynamometer	Eddy current, 7.5 kW, 1500-3000 rpm,air cooled with a loading unit
Load measurement	Direct coupling, Strain gauge

Table 2: Properties of Blending Stocks

Property	Diesel	HA20	H20	ASTM method
Density @15°C (kgm^{-3})	0.835	0.826	0.838	D4052
Calorific value ($MJkg^{-1}$)	45.4	43.9	43.9	D240
Kinematic viscosity (cSt)	2.15	3.52	4.05	D445

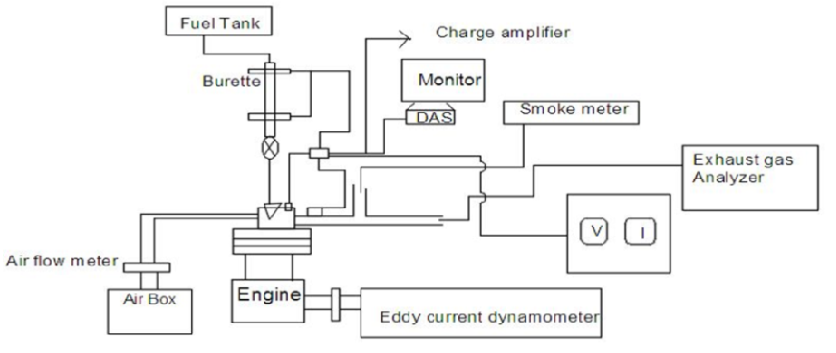

Figure 1: Experimental Setup

RESULTS AND DISCUSSIONS

Brake Specific Fuel Consumption (BSFC)

Figure 2 shows the BSFC for all test fuels. It is observed that the average values of BSFC for diesel, HA20 and H20 are 0.489, 0.496, and 0.521 kg/kWh respectively. BSFC decreases with increase in the load for all test fuels. When compared with diesel, HA20 has shown a marginal increase in BSFC at full load. Also it is observed that BSFC for H20 is higher by 8.47% than diesel at full load. This may be due to the higher viscosity of H20 than diesel.

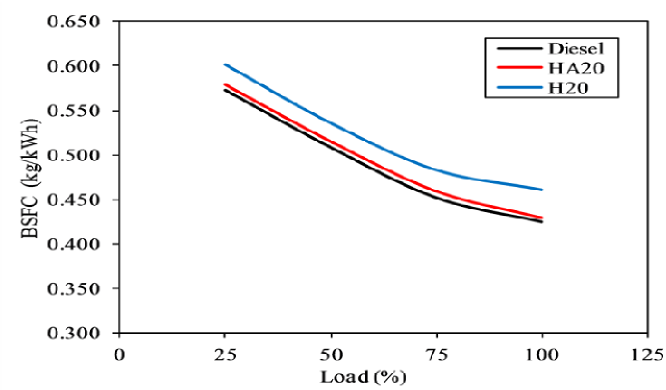

Figure 2: Brake Specific Fuel Consumption Variation with Load

Brake Thermal Efficiency (BTE)

Figure 3 shows BTE variations for all test fuels with a load. It is seen from the figure that BTE increases with the load for all test fuels. BTE is greatly influenced by mass flow rate and calorific value of the fuel. Under full load conditions, BTE for diesel, HA20 ,and H20 are found to be 29.68%, 29.12% and 27.1% respectively. With H20, BTE decreased by 9.5% than diesel. The lower calorific value and higher viscosity might have led to the poor atomization and vaporization of H20. It is also observed that BTE for HA20 is marginally low (1.56%) than diesel. This might be due to the enhanced combustion with the effect of dicyclopentadiene, which lets to have the desired atomization and vaporization of the fuel.

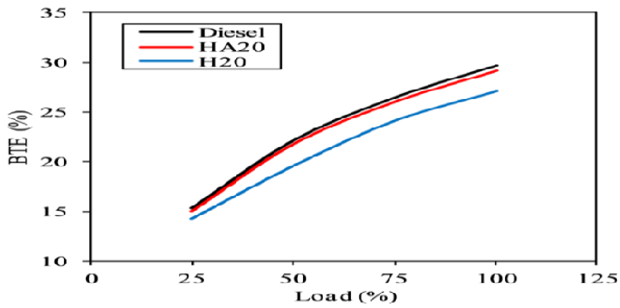

Figure 3: Brake Thermal Efficiency Variations with Load

Oxides of Nitrogen

Figure 4 shows the NO_x variations of all test fuels with a load. It is clear from the figure that NO_x emission for all test fuels increases with increase in the load. It is also observed that NOx emission for H20 is higher than other fuels. The average values of NOx for diesel, HA20, and H20 are 0.9086, 0.714 and 1.1352 g/kWh respectively. Under full load conditions, the peak combustion temperature is higher in H20 than other fuels. As such, NOx emission recorded is higher for H20 than other fuels. It is found that NO_x emission increased by 23.25% with H20 than diesel. On the other hand, NOx emission for HA20 is lower by 17.63% than diesel.

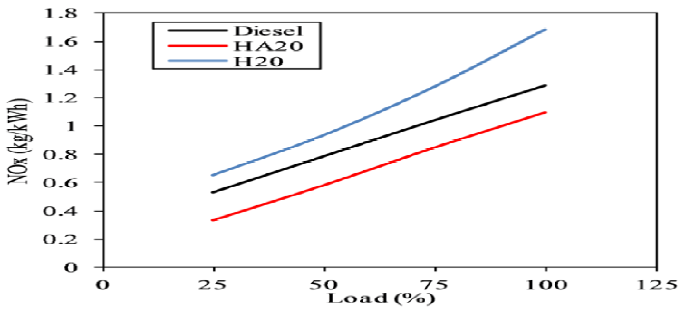

Figure 4: NO_x Variations with Load

Hydro Carbon (HC)

Figure 5 shows HC variations for all test fuels with the load. The parameters that influence the formation of HC are fuel properties, spray characteristics and engine operating conditions. It is seen from the figure that average HC emissions for diesel, HA20, and H20 are 0.045, 0.041 and 0.051 respectively. There is 6.2 % decrease in HC emission with HA20 than diesel. The oxygen content in hazelnut biodiesel and improved combustion with dicycloepentadiene might have provided an additional advantage which enhanced the oxidation unburned HC.

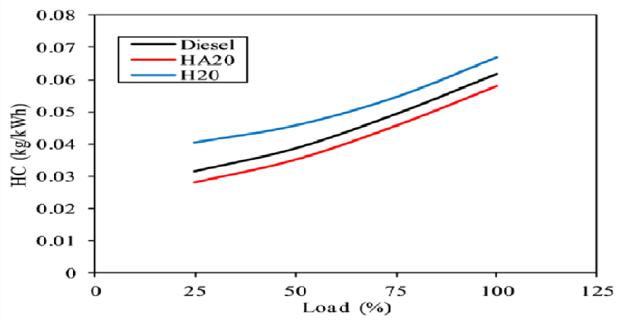

Figure 5: Hydro Carbon Emission Variations with Load

Carbon monoxide

Figure 6 shows the variations of CO with the load for all test fuels. The formation of CO is influenced by the amount of air available and mixing of fuel and air. It is observed from the figure that average values of CO for diesel, HA20, and H20 are 0.6725%, 0.47% and 0.505% respectively. it is also observed that CO emission with HA20 is lower than diesel by 35%. Lower CO emission for HA20 than other fuels may be attributed to the combined effect of additional oxygen in hazelnut biodiesel and higher cetane number of the fuel.

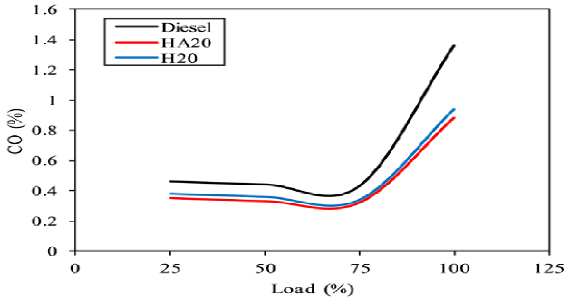

Figure 6: Co Variations with Load

Smoke

Figure 7 shows the smoke emission variations with a load for all test fuels. It is seen from the figure that average smoke emission for diesel, HA20, and H20 are 2.70, 2.37 and 2.97 FSN respectively. With HA20, smoke emission reduced by 15.56% than diesel. This reduction in smoke might be due to the additive.

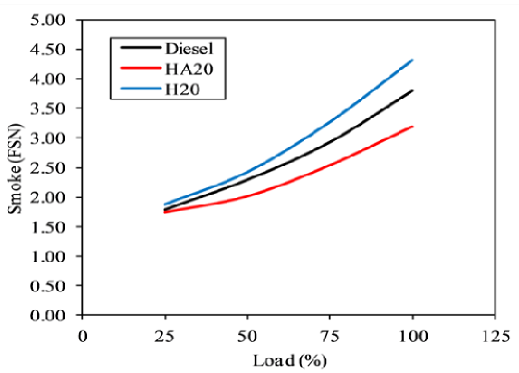

Figure 7: Smoke Emission Variations with Load

Exhaust Gas Temperature (EGT)

Figure 8 shows the EGT variations with a load for all test fuels. EGT is an important parameter that reveals the combustion phenomenon. EGT is higher for H20 than other fuels. This might be due to the delayed combustion with H20. The poor atomization due to the higher viscosity of H20 might also have influenced for higher EGT.

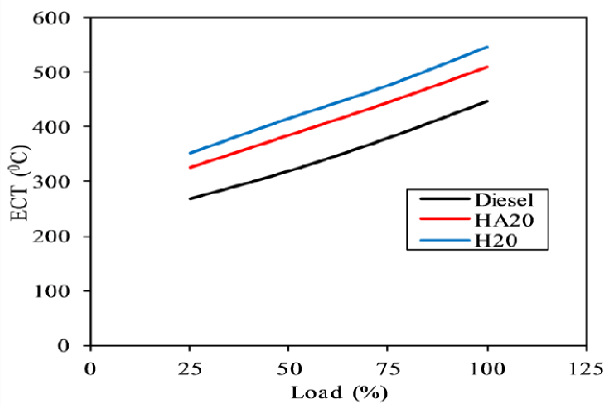

Figure 8: Exhaust Gas Temperature Variations with Load

CONCLUSIONS

When compared with diesel, HA20 has shown a marginal increase in BSFC at full load. Also, it is observed that BSFC for H20 is higher by 8.47% than diesel at full load. With H20, BTE decreased by 9.5% than diesel. The lower calorific value and higher viscosity might have led to the poor atomization and vaporization of H20. It is also observed that BTE for HA20 is marginally low (1.56%) than diesel. NOx emission recorded is higher for H20 than other fuels. It is found that NO_x emission increased by 23.25% with H20 than diesel. On the other hand, NOx emission for HA20 is lower by 17.63% than diesel. There is 6.2 % decrease in HC emission with HA20 than diesel. CO emission with HA20 is lower than diesel by 35% With HA20, smoke emission reduced by 15.56% than diesel

REFERENCES

1. *P. Bridjesh, N. Prabhu Kishore, M. V. Mallikarjuna, N. Alekhya, Performance Analysis of Variable Compression Ratio Diesel Engine using Calophylluminophyllum Biodiesel, Indian Journal of Science and Technology, September, 2016.*
2. *N. Prabhu Kishore, N. Alekhya, P Bridjesh, Experimental Investigation by Varying Fuel Injection Pressure on CI Engine, Materials Today: Proceedings 4, 8394–8399, 2017.*
3. *N. Prabhu Kishore, N. Alekhya, J. Krishnaraj, Bridjesh. P, V. Anil Kumar, Experimental Analysis of CalophyllumInophyllum Biodiesel Blends on Variable Compression Ratio Diesel Engine, International Journal of Mechanical Engineering and Technology, 8(7), 225-230,2017.*
4. *Bridjesh P, Periyasamy P, Mallikarjuna M V, Selecting Optimal Combination of Operating Parameters of Diesel Engine Using Analytic Hierarchy Process, Materials Today: Proceedings 4, 7457–7466, 2017.*
5. *R. Senthil, E. Sivakumar, R. Silambarasan, G. Mohan, Performance and emission characteristics of a low heat rejection engine using Nerium biodiesel and its blends, International Journal of Ambient Energy, 2015, DOI: 10.1080/01430750.2015.1076517.*
6. *Metin G, Mustafa Atmaca, Use of Hazelnut Kernel Oil Methyl Ester and Its Blends as Alternative Fuels in Diesel Engines, Turkish J. Eng. Env. Sci. 32, 133 – 141, 2008.*
7. *Uyaroglu A, Uyumaz A, Çelikten, I, Comparison of the combustion, performance, and emission characteristics of inedible Crambeabyssinica biodiesel and edible hazelnut, corn, soybean, sunflower, and canola biodiesels. Environ. Prog. Sustainable Energy, 2017. doi:10.1002/ep.12794*

8. *V.Sriram et al.,, Engine Performance and Emission Characteristics of 1-Octanol Blended Bio-Diesel in a Single Cylinder Diesel Engine, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), Volume 7, Issue 6, November - December 2017, pp. 623-630*

9. *Abdurrahman Saydut, Sait Erdogan, Aylin Beycar Kafadar, Canan Kaya, FiratAydin, Candan Hamamci, Process optimization for production of biodiesel from hazelnut oil sunflower oil and their hybrid feedstock, Fuel 183,512–517, 2016.*

10. *EfeSü, AkifCeviz M, Temur H, Comparative engine characteristics of biodiesels from hazelnut, corn, soybean, canola and sunflower oils on di diesel engine, Renewable Energy, 2018, doi: 10.1016/j.renene.2017.12.011.*

11. *Y. X. Xu, M. A. Hanna, Synthesis and characterization of hazelnut oil-based biodiesel, Industrial Crops and Products 29:2-3, 2009, pp. 473-479; doi: 10.1016/j.indcrop.2008.09.004.*

12. *MevlütSüreyyaKoçak, ErolIleri, ZaferUtlu, Experimental Study of Emission Parameters of Biodiesel Fuels Obtained from Canola, Hazelnut, and Waste Cooking Oils, Energy & Fuels, 2007, 21, 3622–3626.*

13. *Demirbas, Oils from Hazelnut Shell and Hazelnut Kernel Husk for Biodiesel Production, Energy Sources, Part A, 30:1870–1875, 2008, DOI: 10.1080/15567030701457467*

14. *AlpaslanAtmanli, Effects of a cetane improver on fuel properties and engine characteristics of a diesel engine fueled with the blends of diesel, hazelnut oil and higher carbon alcohol, Fuel 172 (2016) 209–217*

15. *Bridjesh P et al., MEA and DEE as additives on diesel engine using waste plastic oil diesel blends, Sustainable Environment Research (2018), https://doi.org/10.1016/j.serj.2018.01.001*